APPENDIX B -- HISTORICAL VEGETATION DISTRIBUTION ALONG THE NORTHWEST FORK OF THE LOXAHATCHEE RIVER

Aerial Photography/GIS Study Methodology

Existing historical aerial photography was used to compare spatial and temporal changes in the distribution and abundance of vegetation communities along the floodplain of the Northwest Fork of the Loxahatchee River, document changes in vegetation cover, and correlate those changes to major events in the watershed. This study examined 1940, 1953, 1964, 1979, 1985, and 1995 aerial photographs to determine the vegetative distribution during each decade. The 1940, 1979, 1985, and 1995 aerial photographs were specifically chosen because those dates correspond to a time prior to the permanent opening of the Jupiter Inlet, times before and after enactment of Minimum Flows and Levels legislature, and the Federal Wild and Scenic designation, and the most recent photograph available, respectively. The black and white aerial photographs taken in 1940 were compared to color infrared photographs taken in 1985 and 1995 to quantify changes in the distribution and abundance of freshwater hardwood, cypress and mangrove communities between river miles 4.5 and 11.2. For comparison purposes, total acreage of vegetation types was analyzed within six segments of the 1940 and 1995 coverages. The 1953, 1964, and 1979 aerial photographs were also digitized and compared with photography from 1940, 1985 and 1995 between river miles 6.6 and 8.9.

The 1940 aerial black and white photographs (Accession Numbers CJF 3-51, 17-53, 17-54), which were taken on August 21, 1940 at a scale of 1:40,000 were obtained from the National Archives (College Park, Md.). The 1953, 1964, and 1979 photographs were obtained from the U.S. Department of Agriculture, Consolidated Farms Service Agency in Salt Lake City,

Utah. The 1985 color infrared photographs were obtained from a special flight conducted for the SFWMD by Abrams Aerial Survey Corporation on April 27, 1985, at a scale of 1:400 over Lake Okeechobee and portions of the Loxahatchee River Watershed. Eight photographs from the 1985 survey were scanned to produce the floodplain coverage. The 1995 aerial photographs (Accession Number NAPP 6966-089) were taken on January 26, 1995, at a scale of 1:40,000 and the Digital Ortho Quads (DOQs) were obtained from the National Aerial Photography Program. The 1940 photographs were scanned at a scale of 3' per pixel and georeferenced to the 1995 DOQQ's. The 1995 aerials for the DOQQ's were scanned at a 1 meter-pixel resolution and rectified to meet a 1:12,000 scale accuracy for the quarter quadrangles. All imagery was produced in the State Plane Coordinate System, Florida East Zone, 1983 Datum. The floodplain areas between RMs 6.6 and 8.9 were digitized for the 1979 photograph. The total vegetative community coverage by type and by year was compared over time to quantify changes in vegetative types over this 55-year period.

Plant community signatures utilized in this study were adopted from the Florida Land Use, Cover and Forms Classification System (FLUCCS), Florida Department of Transportation, 1985 (**Table B-1**). Color and texture descriptions listed in the reference document were compared with known vegetation from the 1995 aerial to establish the following list of observed classifications:

Vegetative Coverages

428 Cabbage Palm
500 Water
510 Streams and Waterways
612 Mangrove Swamp
615 Stream Swamp
617 Mixed Hardwoods
621 Cypress
641 Freshwater Marshes
700 Barren Land
740 Disturbed Land

Using these categories, major plant communities were delineated into distinct aerial units characterized by specific tones and textures. Image tones refer to the brightness of an area of background as portrayed by the film in a given spectral region (or in three spectral regions for color or color infrared). Image texture refers to the apparent roughness or smoothness of an image region. Texture is produced by the pattern of highlighted and shadowed areas as an irregular surface is illuminated from an oblique angle. Mature forest appears as rough texture, while agricultural fields appear as smooth texture. Categories such as cypress may be recognized by the distinctive shape of the pin-like crowns of some trees (Campbell, 1987).

To validate the images produced by the major plant community-types in the floodplains and associated upland communities, groundtruthing and field observations were conducted from a helicopter in October and November 2000 and from ground surveys in November and December 2000 and April 2002.

Table B-1. Major Plant Communities and Signatures for Color Infrared Photos

Major Plant Communities	Signature	Vegetation	Hydrology/Soils
300 Rangeland 321 Palmetto Prairies	Bright pink, stippled appearance	Saw palmetto (*Serenoa repens)* is the dominant species. Other potential species: bluestems (*Andropogon spp.)*, panic grasses (*Panicium spp.*), fetterbush (*Lyonia sp.*), gallberry (*Ilex glabra*), and wax myrtle (*Myrica cerifera*)	Good drainage, seldom inundated
400 Upland Forest 428 Cabbage Palm	Dull, medium red color return with a predominantly fluffy and irregular crown texture with individual crowns discernable	cabbage palms with live oaks and vines	Rarely inundated/ fine sands well to somewhat poorly drained
500 Water 510 Streams and Waterways	black color for rivers streams, creeks, canals and other water bodies		
600 Wetlands 612 Mangrove Swamp	Smooth "cottony" red with generally even height* Areas of stress may appear as bright greenish color with a rough or stipple texture	Dominated by red, white or black mangroves (red towards the water's edge, blacks toward the landward side, whites more landward Other species Buttonwood, seagrape, palms, brazilian pepper, cocoplum	Permanently to tidally flooded/ very poorly drained organics or saline sands
615 Stream & Lake Swamps	Varying size canopies of irregularly shaped crowns from very pin-like (cypress) to mid-size fluffy and cottony overlapping crowns of broad leaf deciduous hardwoods. Cypress greyish green other hardwoods red color returns	Dominated by a mixture of water tolerant hardwoods including red maple, water oak, sweetgum, willows, water hickory, bays Cypress present but not dominant	Seasonal inundation depending upon weather cycles/ Soils mixture of sand, organics, and alluvial materials
616 Inland Ponds & Sloughs	Similar return as 615; however, these areas are found in depressions (ponds) and poorly drained defined drainages (sloughs) not associated with rivers or creeks	Dominated by cypress, red maples, willows with no single species dominating	Semi-permanent or permanent hydroperiods with a few inches of slowly moving water/ Soils highly organic sands or layered
621 Cypress	gray or gray-green color, narrow, densely packed crowns Tallest trees near the center with younger smaller trees along the edges	Dominated by cypress bald or pond Other species: red maple, pond apple, pop ash, water hickory In drier sites laurel oaks, sweet gum and bays	Semi-permanent or permanent hydroperiods/Poorly or very poorly drained, high in organics with peat layer of varying thickness on the surface
641 Freshwater Marshes	Variable, black open water, areas of faint pink to white return (floating aquatic vegetation), other vegetation pink to red range producing a smooth to stippled texture Sawgrass and cattail greenish to greenish-white return	Dominated by herbaceous vegetation including maidencane, common reed, cordgrass, bullrush, sawgrass and cattails with some pickerelweed and arrowhead	Seasonally to permanently flooded, may dry out during droughts/ Very poorly drained, mineral or organic

*We noted that darker tones of red within the mangrove community appeared to be taller/older trees that had not been as impacted by past freezes. These areas could be found generally in the interior of the communities and had perhaps been shielded from the colder temperatures and stronger wind.

Results & Discussion

1940 Vegetative Cover

Figure B-1 and Table B-2 (column 2) provide summaries of the major vegetation communities found along the Northwest Fork and adjacent areas (including the floodplain, wetlands in Jonathan Dickinson State Park [Wilson Creek] and some uplands) in 1940, based on a review of historical black and white aerial photographs. **Table B-2** summarizes the coverage (in acres) and changes in coverage of each community type for 1940, 1985 and 1995.

Figure B-1. 1940 Loxahatchee River Watershed (c. 1940)

Table B-2. Interpreted vegetation coverages (acres) for 1940, 1985 and 1995 for the Northwest Fork and adjacent areas, from river miles 4.5 to 11.2, based on aerial photography.

VEGETATION	1940 Coverage	1985 Coverage	1995 Coverage	Acres Difference 1940-1985	Acres Difference 1940-1995	Acres Difference 1985-1995
Freshwater Plant Communities						
Swamp Hardwood Cypress Stream Swamp**	467	338	326	-129	-141	-12
Inland Ponds and Sloughs	59	39	39	-20	-20	0
Freshwater Marsh	NA	5	2	NA	NA	-3
Cabbage Palm	3	7	4	+4	+1	-3
Category Total	***529***	***389***	***371***	***-145***	***-160***	***-18***
Saltwater Tolerant Plant Communities						
Mangrove	163	161	152	-2	-11	-9
Other						
Disturbed or Cleared Lands	27	84	84	+57	+57	-0
TOTAL	**719**	**635**	**607**	**-90**	**-114**	**-27**

*Coverage in acres
** Since swamp hardwood, stream swamp and cypress communities could not be accurately distinguished in the 1940's photographs, these subcategories were combined to provide a basis for comparison.

Results show that the watershed was relatively undeveloped in 1940. The most obvious features are the extensive freshwater swamp, the mangrove swamp located primarily downstream of river mile 7.8, the abundance of wetlands associated with sloughs and ponds, and the overall lack of urban development throughout most of the watershed.

Table B-3. Population as Reported in the U.S. Census in the Loxahatchee River Watershed

Municipality (Incorporation dates)	**Year**						
	1940	**1950**	**1960**	**1970**	**1980**	**1990**	**1999***
Juno Beach (1953)	-	-	249	747	1,142	2,172	2,903
Jupiter (1925)	215	313	1,058	3,136	9,868	24,907	33,925
Jupiter Inlet Colony(1959)	-	-	242	396	378	405	416
Jupiter Island (1953)	-	-	114	295	364	549	561
Palm Beach Gardens (1959)	-	-	-	6,102	14,407	22,990	34,557
Tequesta (1957)	-	-	199	2,642	3,685	4,499	5,122
Total	**215**	**313**	**1,862**	**13,318**	**29,844**	**55,522**	**77,484**

*Estimated by Bureau of Economic and Business Research, University of Florida

According to the 1940 U.S. Census, the Town of Jupiter contained 215 residents (**Table B-3**). Interstate 95 and the Florida Turnpike had not yet been constructed. The major roads at that time were Center Street, State Road 706 (Indiantown Road), State Road 710 (Beeline Highway), U.S. Highway 1, State Road 708 (Bridge Road) and Northlake Boulevard. Although the C-18 Canal had not yet been constructed, there was evidence of ditching from the Loxahatchee and Hungryland Sloughs to the River. The Jupiter Inlet was open in the 1940 photograph, but the presence of sandbars probably reduced the amount of saltwater coming in during high tides. The inlet was not permanently stabilized for navigation until 1947. On the Northwest Fork, tides, winds and periodic storm events may have had sufficient effects upstream past the mouth of Kitching Creek to promote growth of what appear on the photographs to be mangroves along the northern river bank, extending upstream to river mile 7.8. In **Figure B-2**, the 1940's distribution of the swamp hardwood (dominated by cypress) community is color-coded green, while mangroves are color-coded orange. This coverage represents our earliest photographic record of the distribution of mangroves and freshwater communities. Freshwater communities begin to disappear downstream of river mile 7.8 as mangrove became more common. The last remnant of freshwater swamp vegetation occurs at river mile 5.8.

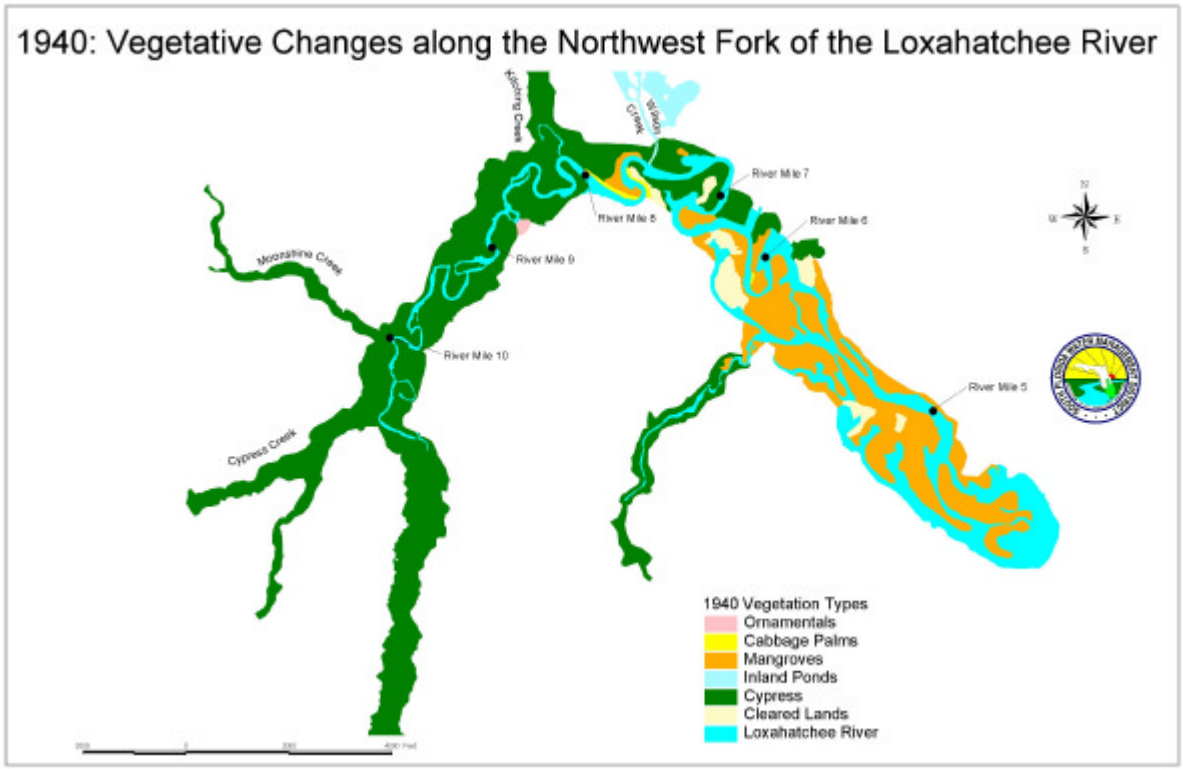

Figure B-2. 1940 Vegetation

Flow from the three main tributaries of the river and runoff from the surrounding lands feed into the northern loop of the river. The uplands and sloughs provide a network of interconnecting lakes, ponds and wetlands (**Figure B-1**) that feed into these tributaries. There are extensive wetlands (prairies and four major sloughs) between Kitching Creek, the North Fork, and Bridge Road at the north end of Jonathan Dickinson State Park in Martin County. Two of the sloughs appear to connect the North and Northwest Forks. These four areas historically may have provided sources of surface water flows to the river, but only Wilson Creek is still connected to the river today. Other visible hydrologic characteristics identified in the 1940 photographs included the following (refer to **Figure B-1** for location of features):

- On the Northwest Fork, Hobe Grove Ditch was not present in 1940, but Moonshine Creek was apparent and drained a wetland slough to the north
- No citrus was grown near the river as it is today, but there was extensive land clearing north of SR 706 on the east side of the Northwest Fork perhaps for agriculture
- A wetland slough connected Jones Creek to Lake Worth Creek (in the vicinity of what is today Frenchmen's Creek)
- Jones and Sims Creeks were lined with mangroves south of SR#706
- The Southwest Fork was a meandering creek that appeared to be dominated by mangroves
- The Southwest Fork/Limestone Creek had been ditched but not channelized
- Mangroves bordered the North Fork and transitioned into freshwater vegetation in the vicinity of today's park. The floodplain was very narrow in the mangrove areas
- There were very few mangrove islands in the embayment area
- Spoil mounds were evident along the Lake Worth Creek and the lower Indian River Lagoon from the dredging of the Atlantic Intracoastal Waterway channel

An estimate of the location of Interstate 95 and the Florida Turnpike was made to define the southern boundary of the study area in the 1940 photo. Unlike the clarity of later black and white infrared photography that was taken in the 1950s and 1960s, it was difficult to identify plant species other than cypress and cabbage palm within the freshwater communities. In addition, the 1940 photographs were taken during August, when all trees would have full canopies. Most subsequent aerial photographs were taken during the winter months when trees, like cypress, are dormant and very distinguishable. Thus in **Table B-2,** total acreage of cypress was combined with other freshwater vegetation to compare 1940 with 1985 and 1995 coverages.

In this study, the category of cypress represents a community dominated by cypress (more than 50% coverage) but that also may contain red maple, pond apple, pop ash, water hickory, laurel oak, and bay trees. The category of stream swamp represents a freshwater community of primarily mixed hardwoods with cypress (present but not dominant). Cabbage palms, which are normally associated with upland communities, are found within tidally inundated to seldomly inundated areas of the floodplain along the Northwest Fork of the Loxahatchee River. During the 2000 field observations, it was noted that those cabbage

palms still surviving in inundated areas did not appear as healthy as those did at higher elevations.

Table B-2 and **Figure B-2** show that in 1940, there were about 163 acres of mangroves and 467 acres of cypress and stream swamp within the floodplain. Of the total 720 acres of floodplain vegetation identified in the 1940 aerial photography, 65% was represented by the stream swamp and cypress community while mangroves represented about 23%. Disturbed or cleared land represented 27 acres or about 4% of this coverage. Mangroves dominated the floodplain between river miles 4.5 and 6.0 and were present up to river mile 7.8. Stream swamp and cypress were present upstream from about river mile 6.5 and were dominant above river mile 8.0.

1985 and 1995 Vegetation Communities

Beyond the obvious publicly owned lands and agricultural fields, the eastern portions of the Loxahatchee River Watershed were highly urbanized by 1985 and 1995 (see **Figure 8 – Main Document**). A 1999 census estimate showed that the Town of Jupiter had a population of 33,925 residents within the city limits. Jupiter residents plus neighboring municipalities accounted for a total of 77,484 residents (**Table B-3**). This number, however, does not include the residents of unincorporated Palm Beach County in the western portion of the watershed (e.g. Jupiter Farms). According to the Palm Beach County Planning and Zoning Department records, the 1999 census estimated an additional 10,506 residents in Jupiter Farms and 3,536 in Palm Beach Country Estates. Interstate 95 and the Florida Turnpike stand out as major features that bisect the landscape along with extensive areas of agriculture (primarily citrus and cattle grazing), and the 11,471 acres of Jonathan Dickinson State Park.

Whereas in the 1940 black and white photographs the canopy appeared to be very uniform among swamp hardwood areas, in the 1995 photographs, the canopy seemed to have varying heights, colors and textures. Field observations showed that while some remaining areas maintained more than 50% cypress coverage, other freshwater communities consisted of mixed hardwoods including red maple (*Acer rubrum*), water hickory (*Carya aquatica*), laurel oak (*Quercus laurifolia*), pond apple (*Annona glabra*), pop ash (*Fraxinus caroliniana*), dahoon holly (*Ilex cassine*), and bay (*Persea* spp.) that are characteristic of a freshwater hardwood swamp. These areas were designated as “stream swamp” in the 1985 and 1995 coverages.

The most striking features noted in the comparison between the 1940 photos and those taken in 1985 and 1995 were as follows: a) the dredging and filling of former mangrove islands between river miles 4.5 and 5.5; b) the loss of floodplain and wetlands due to apparent flow diversions, invasion of upland species and development; and c) the effects of the placement of bulkheads along both shorelines of the estuary and lower Northwest Fork. Also, the islands and oxbows appear to have been heavily scoured over the years. These changes are reflected in total acreage differences between the 1940, 1985 and 1995 coverages. There is an overall loss of approximately 114 acres (17%) of wetland/floodplain area during this 55-year period (**Table B-2**).

Figures B-3 and B-4 illustrate the 1985 and 1995 distributions of vegetation within the floodplain. Color infrared photography allowed for the identification of a greater number of plant categories and better observation of vegetative changes. The 1985 photo represents the distribution of vegetation at the time that the Loxahatchee was designated as Florida's first Wild and Scenic River.

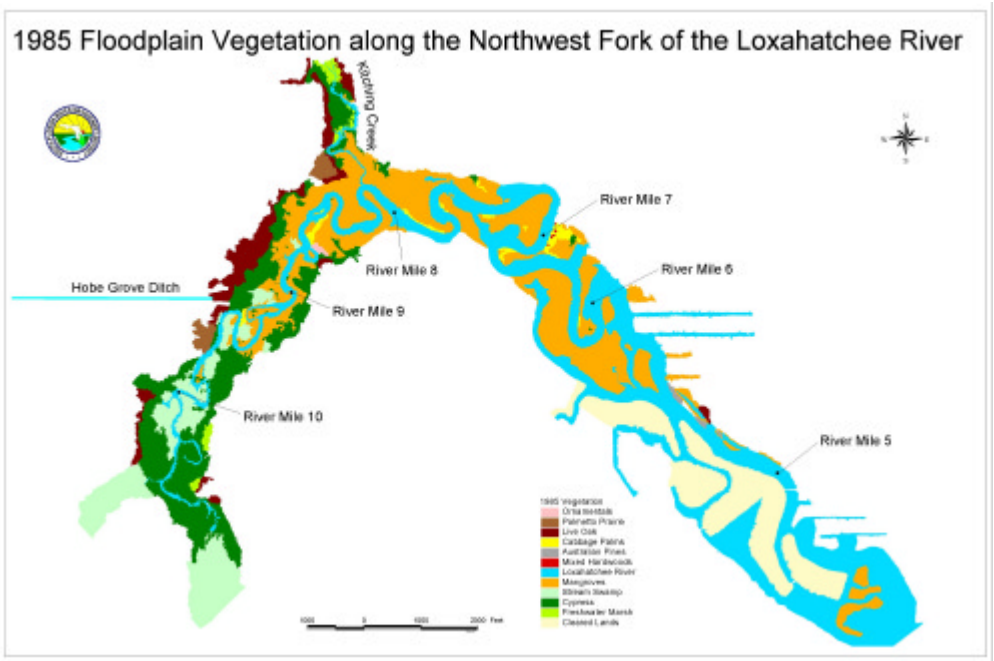

Figure B-3. 1985 Vegetation

Whereas in 1940, mangroves were dominant between river miles 4.5 and 6.5 and were present up to RM 7.8, mangroves became dominant between river miles 5.5 and 8.7 and extended upstream to RM 10.4 by 1985. The floodplain in 1985 included 163 acres of mangroves, which represented 25% of the vegetation coverage in the Northwest Fork, and 390 acres of freshwater vegetation, representing approximately 61% of the coverage (**Table B-2**). Therefore, between 1940 and 1985, there was about a 10% loss of freshwater vegetation and a 4% increase in mangroves within the floodplain area. One would suspect that mangrove encroachment should be higher; however, between 1940 and 1985, there was a loss of mangroves reflected in the category Disturbed and Cleared Land, which increased from 4% in 1940 to 13% in 1985. Also, the floodplain decreased in acreage from 720 acres to 635 acres.

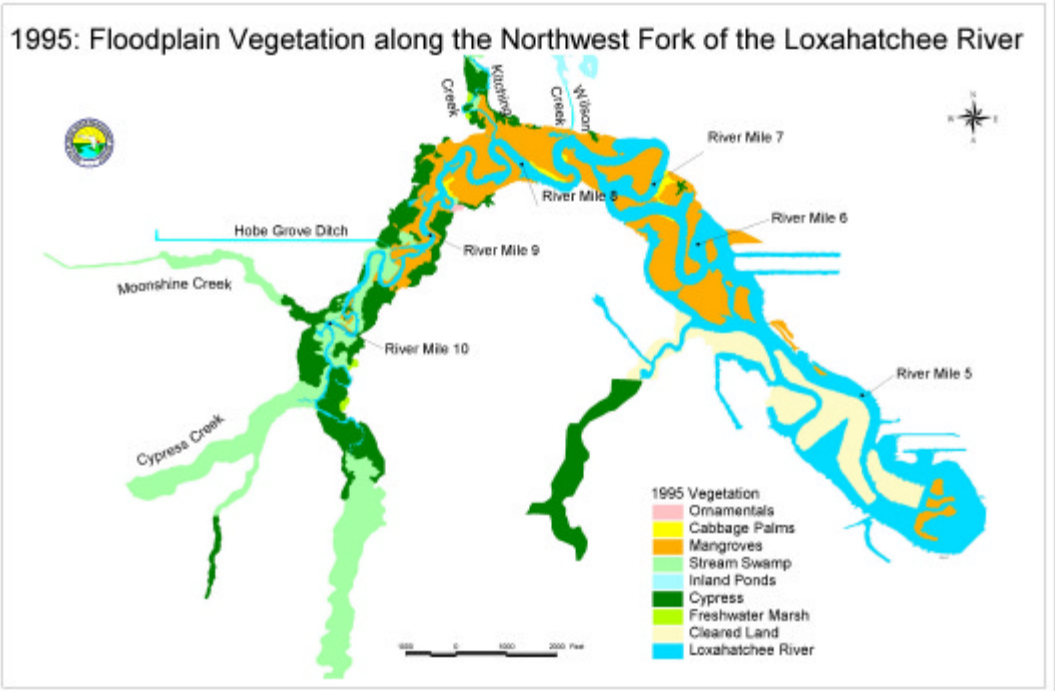

Figure B-4. 1995 Vegetation

There were no major changes in coverage between 1985 and 1995 (**Table B-2**). This relative stability of plant communities may be attributed to two factors. First, in 1987 additional culverts and operational criteria were added to G-92 to reconnect the Loxahatchee Slough with the NW Fork resulting in more water being added to the NW Fork (see section on *Hydrologic and Salinity Conditions* at the beginning of **Chapter 5**). Second, there was above normal rainfall and flow to the river during the 1990s. As a result of these changes, on average, an increase of 30 cfs subsequently delivered through G-92 may have helped to stabilize the distribution of fresh and saltwater communities.

Both the 1985 and 1995 photographs show apparent changes in the distribution of mangroves and freshwater plant community coverages in the Hobe Grove Ditch and Cypress Creek areas. In 1985 and 1995, mangroves were present within the lower portion of Kitching Creek. Near the mouth of the creek, mangroves appear as forests whereas further upstream they appear as understory vegetation with a cypress/cabbage palm canopy. By 1995, there were 152 acres of mangroves (25%) and 371 acres of freshwater vegetation (60%) (see **Table B-2)** along the Northwest Fork (east of Interstate 95 and the Turnpike). Although the total coverage of freshwater vegetation decreased by 144 acres (27%) between 1940 and 1985, only 19 additional acres were lost from this community between 1985 and 1995.

To obtain a more detailed look at changes in freshwater and saltwater communities between 1940 and 1995, District staff divided the River into six segments (Lower NW, Mid NW, Upper NW, Wilson Creek, Kitching Creek, and Island Way Creek (**Figure B-5**).

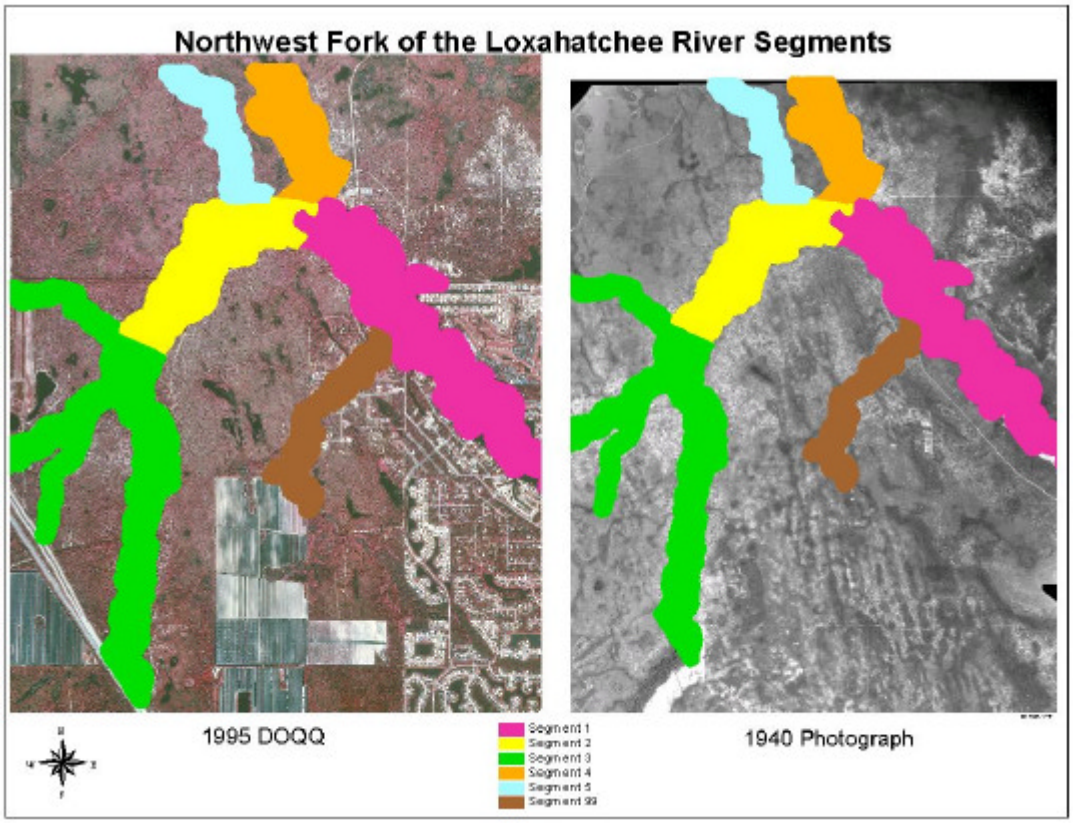

Figure B-5. Location of River Segments

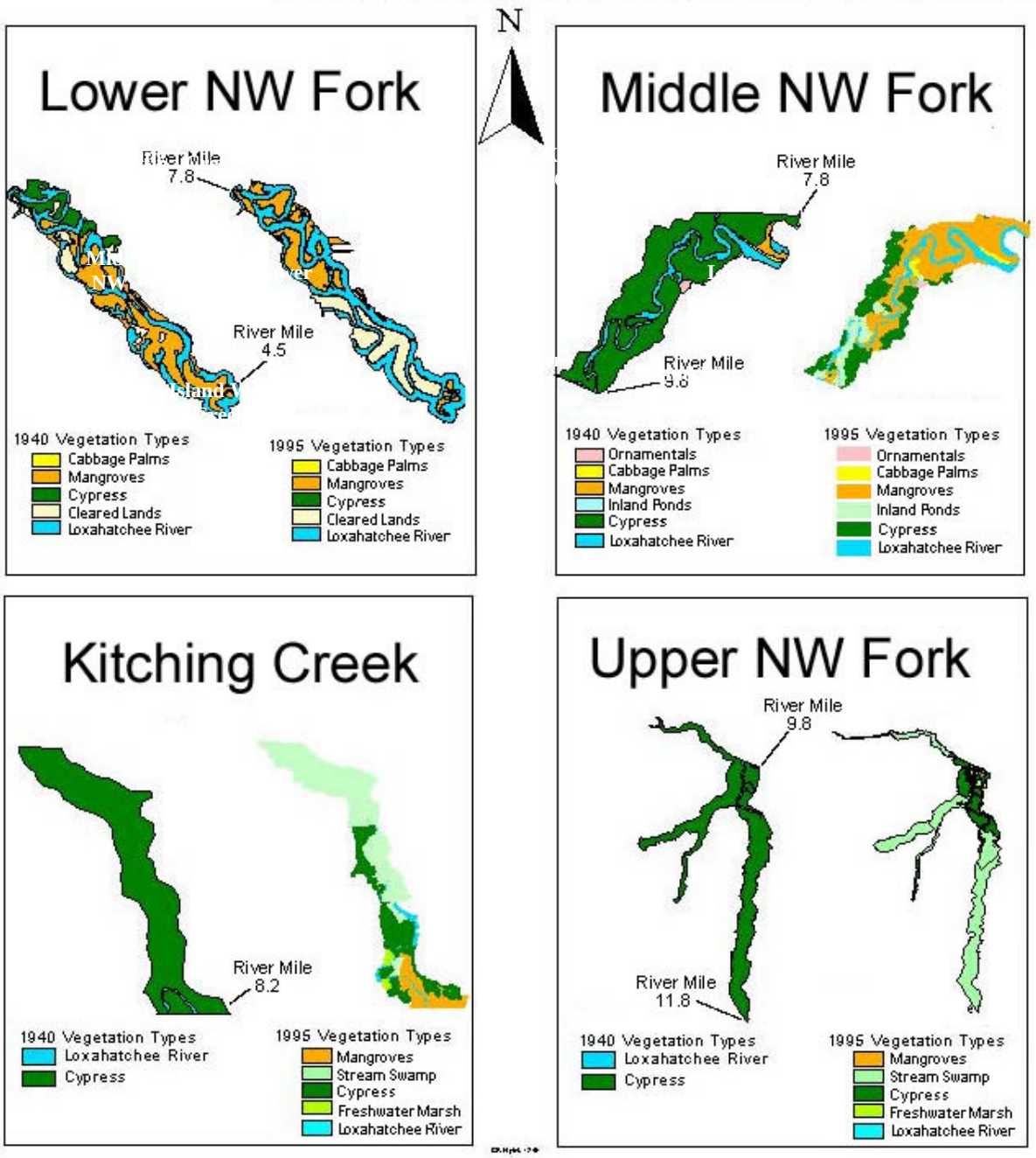

Figure B-6. Comparisons between 1940 and 1995 Coverages by River Segment

Figures B-6, B-7 and **B-8** illustrate the changes in freshwater and saltwater communities and disturbed lands between 1940 and 1995 by river segment. Most of the changes were observed within the Lower and Middle Northwest Fork segments. Between 1940 and 1995, mangroves exhibited both losses and gains (**Table B-2** and **Figures B-6, B-7** and **B-8**) so that the total coverage remained essentially unchanged. Mangroves were lost due to development of islands between river miles 4.5 and 5.5 in the lower segment of the river, including 84 acres in the vicinity of Island Way Bridge. Mangroves increased in coverage upstream, primarily between river miles 6.0 and 8.5 in the middle segment, by invasion into freshwater communities.

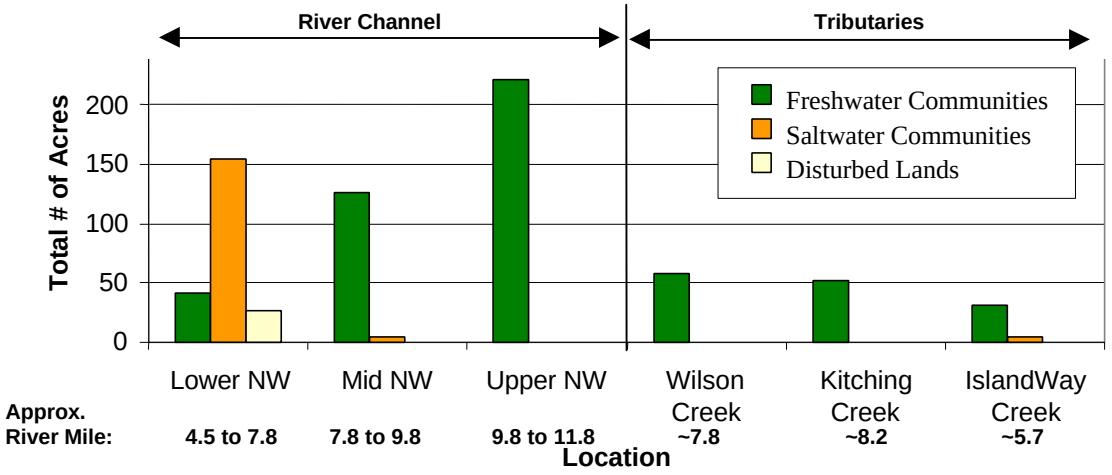

Figure B-7. 1940 Vegetation Coverage along the Loxahatchee River, by Segment

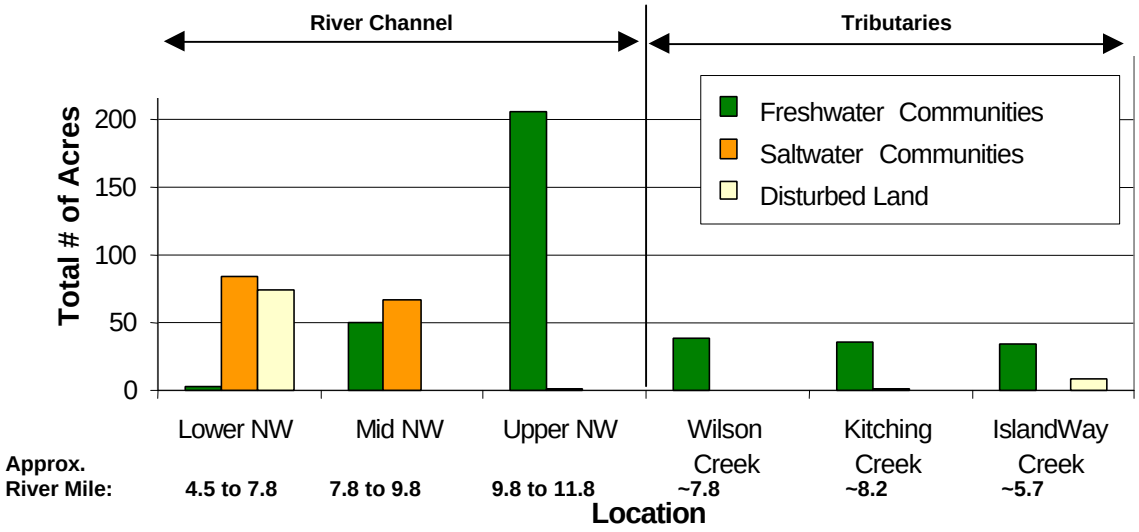

Figure B-8. 1995 Vegetation Coverage along the Loxahatchee River, by Segment.

Freshwater communities were present in all segments, but primarily in the Upper NW segment. Disturbed and/or Cleared Lands were present primarily in the Lower NW segment. Those Disturbed Lands that were not developed reverted to mangrove communities. Brackish

water marsh plants were observed as understory within these communities. As a side note, family photographs taken of plant communities in 1964 and 1966 (personal communication, Richard Roberts, Jonathan Dickinson State Park) provided clear evidence that large areas in the vicinity of the power lines (approximately river mile 6.5) that were brackish water marshes in 1964-66 were taken over by mangroves by 1985.

Six Decade Analysis

In order to provide a more detailed analysis of observed vegetation changes over time, District staff analyzed black and white aerial photographs taken of the Northwest Fork and floodplain, between river miles 6.6 and 8.9, during the years 1940, 1953, 1964 and 1979. These early vegetation coverages were also compared to more recent infrared Digital Ortho Quad photographs that were taken from the watershed during 1979, 1985 and 1995. Results of the six-decade analysis of vegetative changes are summarized in **Figures B-9** and **B-10**. River miles 6.6 to 8.9 represent that area of the river where the majority of the vegetation changes have occurred during the past 55 years. These figures clearly represent the progressive encroachment of mangroves and displacement of freshwater swamp communities that occurred between river miles 6.6 and 8.9.

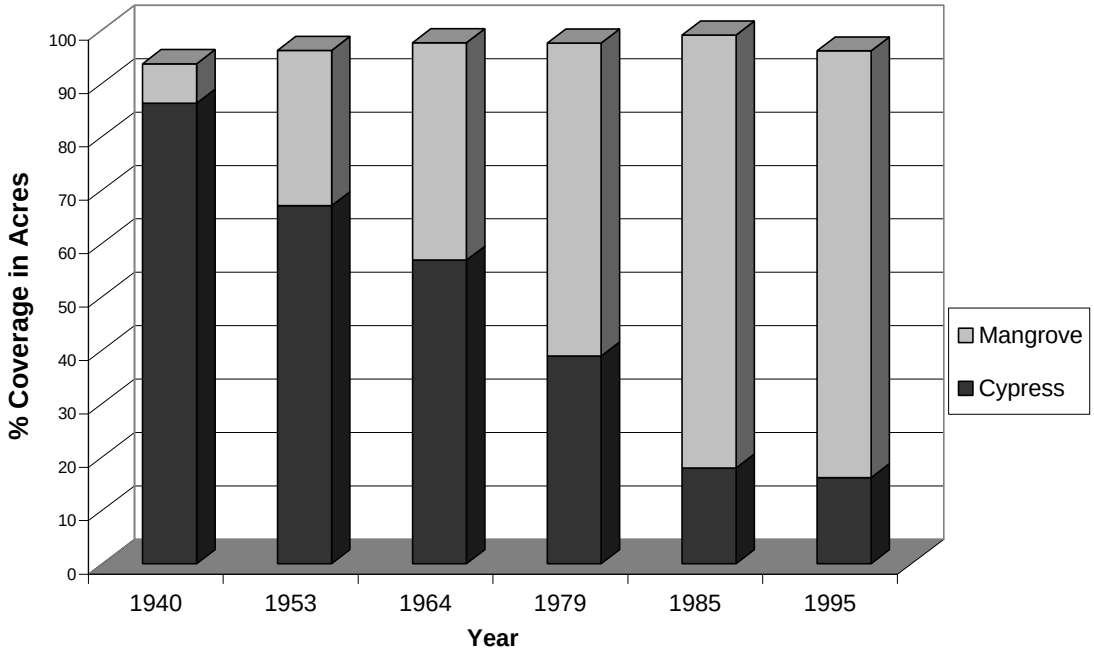

Figure B-9. Mangrove Encroachment between River Miles 6.6 and 8.9.

1953 to 1979 Vegetation Coverages

Details of the 1940, 1985 and 1995 aerial photos were discussed earlier. Aerial photos from 1953 to 1979 were obtained, but were studied in less detail due to limited time and resources. Several overall trends and changes were nevertheless identified from this brief examination (**Figure B-9**). In 1953, mangrove coverage increases substantially in comparison to the 1940 photography. Mangroves represented about 29% of the total area, but still appear to be

absent upstream of river mile 7.8. The coverage of the stream swamp and cypress community has decreased although it is still the largest (67%) category of coverage in the floodplain.

By 1964, the aerial photography shows additional replacement of the freshwater communities by mangroves. Mangroves had colonized the Northwest Fork as far as river mile 8.7 and were present at the mouth of Kitching Creek.

The 1979 photograph shows the continued decline of the freshwater communities and increase in mangrove coverage. Freshwater communities represented only 38% of the coverage. Mangroves had increased to 60% and had advanced to areas above river mile 9, which are located outside (upstream) of the regions shown in **Figure B-10**.

Factors that Influenced Changes in Vegetation

Several field trips to the Loxahatchee River were made during 2000 and 2001 to gain general familiarity with the terrain and to groundtruth plant community signatures. During these trips it was noted that many of the remaining freshwater marsh areas, and Wilson and Moonshine Creeks have been heavily invaded by the exotic Old-World climbing fern, *Lygodium microphyllum*. The *Lygodium* appears to smother existing vegetation. Also, there was apparently a net loss of brackish water marsh habitat, primarily between river miles 6.5 and 7.8 associated with an invasion by mangroves during the 1990s.

The presence of mangroves along the lower NW Fork of the river shown in the 1940 photograph may be the result of several factors. Prior to 1947, the inlet opened and closed periodically. During periods when the inlet was open, saltwater may have had the opportunity to penetrate the lower portion of the river allowing mangroves to become established. Other factors that may have contributed to increased salinity levels within the estuary and lower Northwest Fork prior to 1940 include: (a) construction of the Intracoastal Waterway in 1928 that linked the St. Lucie inlet with the Lake Worth inlet, (b) USACE dredging of the inlet and lower estuary; (c) construction of the Lainhart and Masten dams; (d) construction of Bridge Road, which reduced inflow from Kitching Creek; and (e) construction of a small agricultural ditch that diverted water from the Loxahatchee Slough marsh to the SW Fork of the river.

Several additional changes had occurred in river vegetation by 1953. These changes correspond to the opening of the Jupiter Inlet in 1947, which permanently changed the lower estuary from a freshwater/brackish water system to a salinity regime more characteristic of estuarine conditions (USACE 1966). In addition, back-to-back hurricanes of the late 1940's and their associated high winds and storm surges may have transported mangroves propagules far up river, accounting for some of the mangrove colonization shown in the 1953 photography.

Vegetation changes observed after 1953 are probably related to physical and hydrological changes that occurred in the late 1950's. Between 1957 and 1958, the USACE constructed the C-18 Canal, channelized the Southwest Fork, and constructed the S-46 structure for flood control purposes. These flood control improvements however diverted water away from the Northwest Fork to the Southwest Fork (McPherson et al. 1982). High (spring or wind-driven) tide events, occurring during periods when river flow was reduced, could have transported mangrove propagules upstream. In addition, during the 1960's a developer dredged and filled a

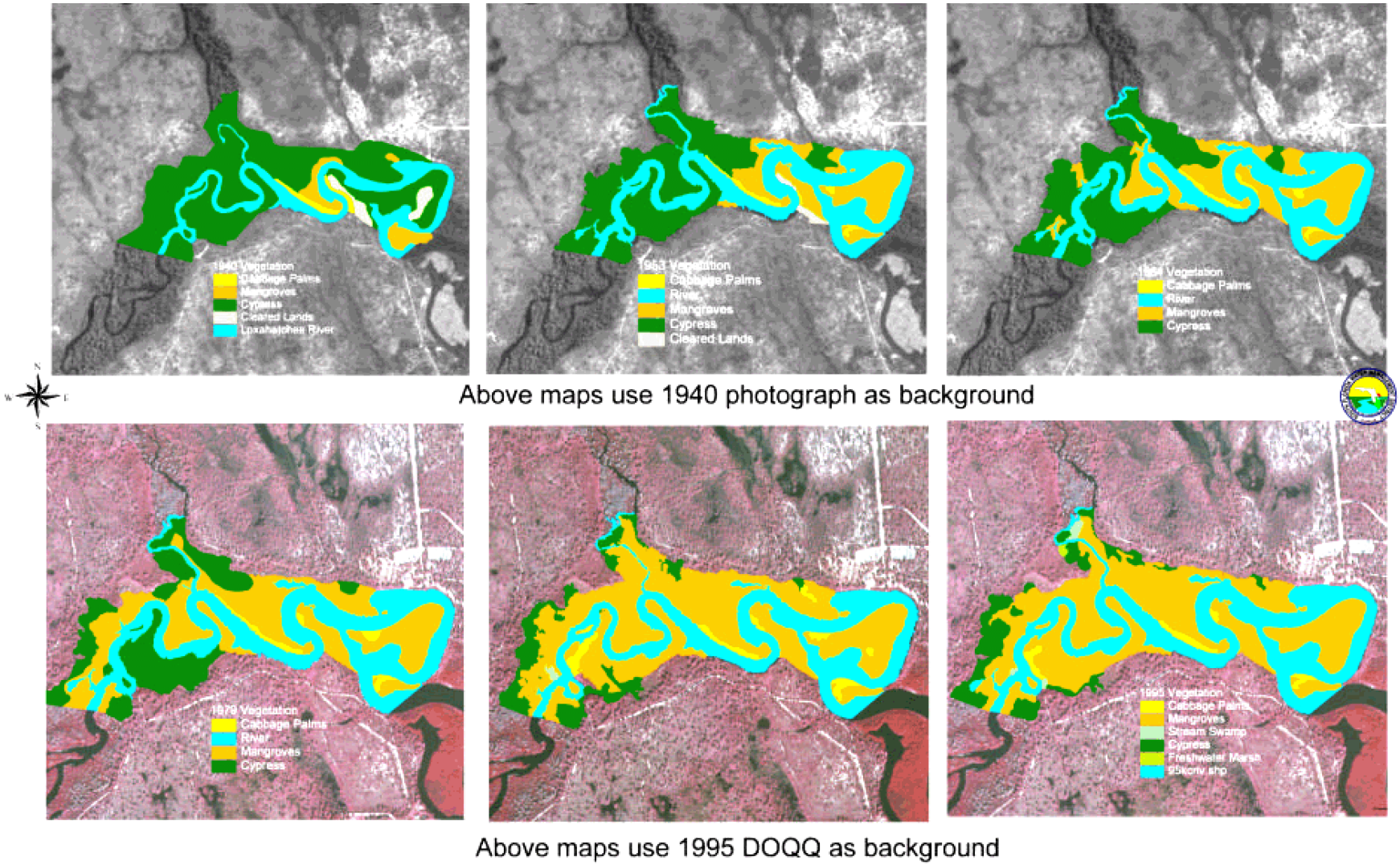

Figure B-10. Vegetation Changes Along the Loxahatchee River between River Miles 6.6 and 8.9, 1940 to 1995

number of mangrove islands within lower portion of the river and cut a channel through the sandbar ("S-bar") that historically provided a natural saltwater barrier between the estuary and the upper reaches of the river. As a result of these projects, saltwater could now more freely penetrate the Northwest Fork of the river during low flow and high tide periods.

Observed vegetation changes that occurred by 1979 correspond with the continued operation of the C-18 canal which essentially eliminated freshwater flow from the Loxahatchee Slough to the Northwest Fork from the time the C-18 canal project became operational (early 1960's) until the construction of the G-92 structure in 1974. In addition, dredging of the central embayment area (McPherson et al. 1982), combined with oyster bar removal projects (Chiu 1975), and replacement of the Alternate A1A bridge over the Loxahatchee River are thought to have improved tidal flushing of the estuary. These projects may have also played a role in allowing saltwater and mangrove propagules to further penetrate the lower portion of the river during dry periods. Review of long-term rainfall records also show that during the 1970's, the region experienced a number of sequential below normal rainfall years that also contributed to the river's saltwater intrusion problems. This timeframe also correlates to the period when small and poor quality rings were formed in cypress trees in the River floodplain (Duever and McCollum, 1982)

The apparent lack of change in the distribution of plant communities between 1985 and 1995 (**Figures B-3** and **B-4)** can be attributed to two major factors: (a) increased flows delivered to the Northwest Fork as a result of conveyance and telemetry improvements made to the G-92 structure in 1987, and (b) increased rainfall experienced within the basin over the past decade **(Figure 4).** These two factors resulted in significantly more water being discharged downstream to the Northwest Fork via G-92 and the Lainhart Dam during the 1990's (**see Figure 19**). Other visible hydrologic or structural changes noted in the 1995 photographs included the following:

- Over 3,000 acres of citrus groves have been planted west of the NW Fork
- Hobe Grove Ditch was dug through uplands to provide flood control for citrus groves during the 1960s. Surface water flowing from this area during dry periods is now being retained to maintain the water table for these irrigation wells.
- Most of the remaining inland ponds and sloughs appear to be much smaller in size in comparison to the 1940 photographs

Impacts of Hydrological Alterations and Meterological Events on Vegetative Changes

Odum et. al. (1982) noted that one generally unrecognized side effect of lowered freshwater flow and saltwater intrusion has been the inland expansion of mangrove forest. The examples that were given included the mangrove borders of Biscayne Bay

and much of the Everglades. These forests have expanded inland since the 1940s in conjunction with man's alteration of surface and groundwater flows.

The permanent opening of Jupiter Inlet, the alteration inflows of surface water, the drop in the groundwater table, and an increase in sea level have promoted the distribution of mangroves and taken their toll on the freshwater habitat of the Northwest Fork of the Loxahatchee River. The altered location of the saltwater interface has produced major changes in vegetative communities. In many areas, mangroves now dominate habitat that was formerly dominated by freshwater cypress and additional changes have occurred within remaining freshwater communities. Urban development within the headwaters and the major tributaries will continue to alter freshwater inflows and make any efforts towards preserving this historical flora more difficult.

Hurricanes have affected the watershed by producing extreme high water levels, opening and closing of inlets, changes in topographical and land contour and by producing severe physical damage to vegetation. Hurricanes have also been known to spread plant propagules over long distances with their waves and high tides. Major hurricanes and tropical storms occurred in the vicinity of the Loxahatchee in 1898, 1903, 1924, 1926,1928, 1933, 1948, 1949, 1964, and 1979. The 1903 storm created an 8-foot storm surge in Jupiter, while Hurricane David in 1979 created a 5-foot surge with winds gusting at 85 miles per hour (mph). Winds of 153 mph were recorded at the Jupiter Lighthouse during the 1949 storm, which passed through Delray Beach (Barnes, 1998).

Historical heavy frost winters were reported in 1939-40, 1957-58, 1962-63 and 1964-65 (Alexander and Crook, 1975) and in 1977, 1983, 1985 and 1989 (Florida Department of Environmental Protection, 2000). Evidence of a major meterological event was apparent from infrared aerial photographs taken during a special flight for South Florida Water Management District in April 1985. Mangroves along the Northwest Fork were defoliated and trees that were 30 feet tall or more exhibited broken branches and trunks. The average monthly air temperatures for January and February 1985 had fallen to 46º and 52º F, respectively with temperatures ranging as low as 25°F (U.S. Department of Commerce, Climatological Data: Florida). Mangroves do not tolerate temperature fluctuations exceeding 18° F or temperatures below freezing for any length of time (Odum et. al, 1982). They may defoliate after exposure to 45°F or less. This may explain why mangroves along the Northwest Fork of the Loxahatchee River are not reaching the height of mangroves in warmer climates, which can range between 60 and 80 feet.

Although mangroves have taken over a considerable amount of the downstream historical coverage of freshwater vegetation along the Northwest Fork of the Loxahatchee River, the Wild and Scenic River segments of the waterway continue to be a valuable natural resource and tourist attraction with both mangrove and cypress habitats. As in coastal areas, mangroves still provide shoreline stabilization, wildlife habitat, and aesthetic values.

Summary

Results of the comparisons of aerial photographs from 1940, 1985, 1995 and other years showed the following:

- Aerial photography of the watershed from 1940 revealed an abundance of swamps, wet prairies, inland ponds, and sloughs. Mangroves were present from river mile 4.5 to river mile 6.0 and extended upstream to river mile 7.8. Freshwater stream swamp and cypress communities were present upstream from river mile 6.5 and were dominant within the floodplain portion of the study area above river mile 8.0, comprising about 73% of the vegetative coverage of the Northwest Fork, while mangroves represented 22%.
- An apparent reduction in total acreage of the river floodplain between 1940 and 1995 can be attributed to several causes, including scouring of the riverbed, bulkheading, development, and loss of wetland vegetation to transitional and upland species due to flow diversion and lowering of water levels in the watershed. Most of the vegetative changes occurred in the lower and middle segments of the Northwest Fork and were documented by more detailed examination of the area between river miles 6.6 and 8.9
- By 1985, much of the watershed had been developed with the exception of Jonathan Dickinson State Park. Freshwater communities represented 61% of the total coverage. Mangroves represented 25% of the coverage and had become dominant along the shoreline upstream to river mile 8.7. In spite of the increased encroachment of mangroves upstream in the floodplain, mangroves increased only 4% in overall extent due to losses of these plants from urbanization. Freshwater communities decreased by 10%.
- Freshwater flows to the Northwest Fork increased during the period between 1985 and 1995, due to construction and improved operation of the G-92 Structure and increased rainfall. These changes may account for the fact that only minor differences in vegetative coverage occurred during this ten year period.
- Improved aerial photography that was used during 1985 and 1995 made it possible to distinguish differences in structure and composition of the freshwater communities. This improved resolution may account for the apparent increase in number of species and apparent loss of cypress dominance along the immediate river corridor upstream of river mile 9. Such changes could also be explained by the impact of saltwater intrusion and decreased surface and ground water inflow.
- An analysis of six decades of change based on aerial photographs and review of other research studies, indicates that most of the mangrove encroachment seemed to occur between 1953 and 1979. Also during this period, the inlet was stabilized and freshwater flow was redirected from the Northwest Fork to the Southwest Fork of the river for flood control.

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